

DOCUMENT RESUME

ED 415 662

EF 005 014

AUTHOR Wheeler, Arthur E.
TITLE The Maintenance of Heating, Ventilating and Air-Conditioning Systems and Indoor Air Quality in Schools: A Guide for School Facility Managers. Technical Bulletin.
INSTITUTION Maryland State Dept. of Education, Baltimore.
SPONS AGENCY Environmental Protection Agency, Washington, DC. Office of Radiation and Indoor Air.
PUB DATE 1995-07-00
NOTE 9p.
AVAILABLE FROM Maryland State Dept. of Education, School Facilities Branch, 200 W. Baltimore St., Baltimore, MD 21201. (Free to Maryland public schools; \$8 for others).
PUB TYPE Guides - Non-Classroom (055) -- Reports - Research (143)
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Air Conditioning; *Air Conditioning Equipment; Air Flow; *Climate Control; Elementary Secondary Education; Energy Conservation; Energy Management; *Equipment Maintenance; Evaluation Criteria; Heating; *School Buildings; Thermal Environment; *Ventilation
IDENTIFIERS Facility Management; Heaters; *Indoor Air Quality

ABSTRACT

To help maintain good indoor air quality (IAQ) in schools, guidance for the development and implementation of an effective program for maintenance and operation of heating, ventilating, and air-conditioning (HVAC) systems are discussed. Frequently, a building's occupants will complain about IAQ when the temperature or humidity are at uncomfortable levels. Such extremes in humidity or temperature can lead to respiratory distress and other problems. To manage IAQ, facilities managers must take the lead and ensure that an effective plan is in place for dealing with HVAC maintenance and other matters. Such plans usually begin with an IAQ profile, which includes an audit of the HVAC and related systems. Documentation is an important component of the plan, as is ensuring that all personnel are properly trained. HVAC commissioning, in which performance and design are verified using computerized controls to monitor the HVAC system, are other vital aspects of an HVAC plan. When such plans are not in place, or even when plans fail, some of the consequences for IAQ include inadequate ventilation, malfunctioning controls, excessive humidity, odors, and irritating vapors. (Contains 4 figures and 18 sources for further information.) (RJM)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

ED 415 662

THE MAINTENANCE OF
HEATING, VENTILATING AND
AIR-CONDITIONING SYSTEMS AND
INDOOR AIR QUALITY IN SCHOOLS
A GUIDE FOR SCHOOL FACILITY MANAGERS

Prepared By
Arthur Wheeler, PE
Wheeler Engineering

BEST COPY AVAILABLE

July 1995

Maryland State Dept. of Education
Division of Business Services
School Facilities Branch

200 West Baltimore Street
Baltimore, Maryland 21201
(410) 267-0098

PERMISSION TO REPRODUCE AND
DISTRIBUTE THIS MATERIAL IN MICROFORM
AND IN ELECTRONIC MEDIA FOR ERIC
COLLECTION SUBSCRIBERS ONLY
HAS BEEN GRANTED BY

G.A. CRENSON

2A TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

- ☐ This document has been reproduced as received from the person or organization originating it.
- ☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.



Introduction

The objective of this bulletin is to offer guidance for the development and implementation of an effective program for maintenance and operation of heating, ventilating and air-conditioning (HVAC) systems that provides acceptable indoor air quality (IAQ) in school environments. The bulletin is addressed primarily to school facilities management.

Case histories of IAQ problems abound, many caused by maintenance and housekeeping failures, frequently exacerbated by insensitive response, deteriorating into serious, sometimes legal confrontations. The evidence is strong that proper operation and maintenance of school HVAC systems is an imperative.

HVAC & IAQ: The Fresh Connection

People have become increasingly aware that feelings of malaise or more serious illness may have their origin in the quality of the indoor air we breathe.

While the symptoms of stuffiness, sensory irritation, headaches, and fatigue may actually be caused by other factors, indoor air quality most often bears the blame. In many schools, air quality has been identified as the primary cause of these temporary symptoms and as a cause of pathogenic and allergenic illness as well. Resultant physical distress has contributed to absenteeism and reduced productivity, which in the classroom translates to reduced learning effectiveness.

Building occupant complaints of poor air quality are frequently reactions to poor conditions of temperature, humidity or both. Building occupants will generally feel most comfortable within a relatively narrow range of space temperatures, usually between 72 to 75°F. While the comfort range of relative humidity is broader, protracted conditions of above 60%rh promote the growth of fungi and bacteria. Building materials that become damp can become sites of explosive growth of fungi. The increased presence of microorganisms and the toxins they produce can trigger allergic response by sensitive individuals and contribute to the spread of some infectious diseases. Below 25 to 30%rh, respiratory distress and eye irritation may be experienced. High survival rates by

some infectious viruses have been observed at low humidity conditions.

Not all IAQ-attributed complaints can be charged against air conditioning. Poor lighting (both natural and artificial), stress (pop quizzes?), and noise can also produce quite similar symptoms.

The occupants themselves impart both particulate and gaseous contaminants to room air. Building materials and furnishings, especially when new, emit volatile chemicals. Carpets, wall coverings and the internal parts of HVAC units collect dust and organic debris, nurturing microbes that can become aerosolized by traffic and air movement.

An effective plan takes into account:

- Administration commitment
- Staffing resources
- Adequacy of budget

Educational activities in art classes, shops, and science labs may produce offensive, at times toxic, vapors which may be dispersed beyond the generating location. Cleaning agents used in routine or episodic housekeeping and pesticides can be pollutants having an impact on some individuals. Returning air from many rooms to a common air handling unit for reprocessing is an inherent operating characteristic of many air conditioning systems. Efficient filters in the air handlers remove particles from the air stream thereby effectively reducing their concentration within the occupied rooms. Conversely, systems with low efficiency filters will recirculate small particles, such as fungi spores and infectious droplet nuclei, to all spaces served. Poorly maintained HVAC components can collect dirt and become a breeding ground for microbes that can then be distributed through the supply air system.

The fundamental functions of all classroom HVAC systems are to provide a clean, comfortable thermal environment conducive to learning. The concentrations of airborne particulates, vapors, and gases produced within the conditioned spaces are diluted by the supply of "fresh" outdoor air (outdoor air is not always fresh) usually blended with cleaned recirculated air. The intended result is to limit concentrations of contaminants to acceptable levels.

ASHRAE Standard 62-1989, *Ventilation for Acceptable Air Quality*, prescribes rates of outdoor air supply for various building spaces and is the basis for most current building code provisions. Where activities produce odors or toxic fumes, their dispersion can best be controlled at the production site by local exhaust ventilation discharging to the outdoors. Laboratory fume hoods, kiln hoods, and toilet room exhausts are examples of removal of contaminants at their source. Emphasis upon operation and maintenance of these exhaust systems can hardly be overstated.

HVAC air supply and exhaust room ventilation rates should be balanced to create pressure relationships that cause air flow through doorways and other pathways to reduce dispersion of odors and other contaminants. Outdoor air ventilation in excess of the amount of air exhausted positively pressurizes the building to minimize inward leakage of unconditioned outdoor air through window cracks and entrances.

The air being supplied is also cooled or heated to maintain the setting of the room thermostat. Dehumidification in many air conditioning systems only occurs as a consequence of temperature control. Inherent capabilities may be inadequate to maintain the moisture content of the air within the desired humidity range especially in warm, humid climates and, at the low end of the range, in very cold climates. Internal climate control and adequate ventilation start with sound design. Design guidance to meet school classroom thermal requirements is the subject of an earlier Maryland State Department of Education Technical Bulletin, *Selecting HVAC Systems for Schools*.

The intent, concept, capabilities, limitations and standards of performance incorporated in the HVAC design are transferred through construction documents to the mechanical contractor, then upon project completion to the facility management team. Without full transfer of this knowledge, the quest for good IAQ is off to a shaky start.

A statistical analysis of many investigations ranks deficient maintenance highest among the causes of IAQ problems. Poor HVAC maintenance, misapplied energy conservation measures, and control malfunctions are major contributors. Elimination of 80% of all IAQ problems has been attributed to sound design followed by proper maintenance and operation of the HVAC system.



IAQ Management

Teachers, support staff and facilities managers share a common goal of providing a comfortable and healthy indoor environment. Facilities managers have the lead role. That role includes ensuring that occupants recognize this goal sharing. Communication is the key to both establishing and maintaining such a relationship. Management starts with a plan. Elements of the plan relating to HVAC/IAQ include organization structure, job descriptions, establishing channels of communication, maintenance procedures, standardized design criteria, training programs, and investigative protocols. More likely a plan revision or updating of an existing Policy and Procedures Manual may be entailed. The development of an effective plan must take into account:

- Administration commitment
- Staffing resources
- Adequacy of budget

Personnel functions for a specific school must relate to the operation of the school district as a whole with assignments incorporated into the organizational structure of the district. Organizational structures will vary depending upon the district size, number of schools and population served. Regardless, organizations need to be reviewed periodically for effectiveness and updating to take advantage of improvements in management techniques and technology.

Job descriptions for all positions in the operation and maintenance chain detailing responsibilities and their limitations should be clear and understood by all. When tasks demand abilities or time commitments exceeding available department resources, contracting the work with qualified contractors is indicated. This, too, requires advance planning. Requests for bids must be clear and the scope of work fully delineated. Pre-qualification of contractors and products improves quality assurance of the work. The chapter entitled Contracted Services in the referenced book by Petrocelli offers helpful guidance. Delineation of the scope of work by design professionals may be beneficial.

Since IAQ responsibilities extend beyond the Operation & Maintenance organization to the building occupants,

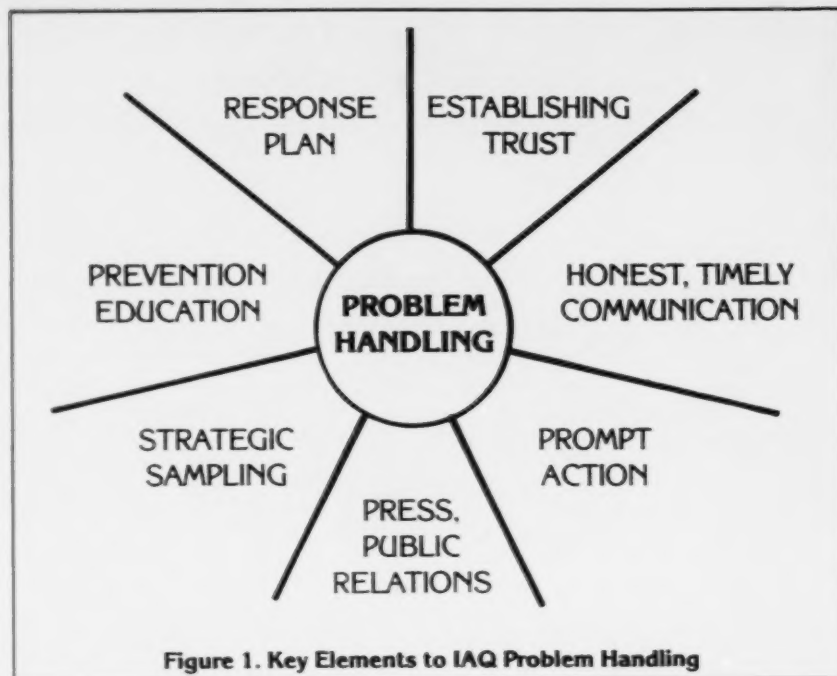


Figure 1. Key Elements to IAQ Problem Handling

communication channels — and their effective use — are the essence of a successful program. Planning is tested when problems occur. Complaints must be responded to promptly, sensitively, and with appropriate follow-up and documentation. Protocols for complaint handling are already well developed and available for adoption. EPA's Guide, containing many useful report forms, is one of several excellent resources listed under References. Responding personnel (principals and teachers included) need instruction on appropriate problem handling. People handling can often make problem-resolution easy or extremely difficult. For Key Elements in a problem-handling program, see Figure 1.

The management plan should set policy and examine procedures for building alterations and renovations. Refer to the Maryland State Department of Education Technical Bulletin, *Maintaining Acceptable IAQ During the Renovation of a School*.

HVAC maintenance budget requests sometimes appear to be an easy item to squeeze. Deferring maintenance to save current expense must be expected to increase future costs greater than the short-term savings and to inexorably reduce the capability of meeting IAQ objectives.

The IAQ Profile

An IAQ profile for every school is the basis for sound planning. These profiles become working documents to guide operation, maintenance and future space planning.

The profile describes all aspects of the school that bear upon IAQ including the HVAC system, occupancy patterns, and usage. Contract documents (plans and specifications), records of building changes, operating and maintenance instructions and related material, if available, form a part of the profile. Focusing upon the HVAC system characteristics, the age, condition, history of past problems, and personnel assignment for IAQ and HVAC responsibilities are pertinent to the profile. Development and compilation of the description and support documentation usually entails an HVAC/IAQ audit described later. The emphasis here is on IAQ, but the profile can cover fire safety, security and other characteristics of a school as well. Start the profile with material that is readily available and build upon it.

The HVAC/IAQ Audit

A comprehensive, current description for the IAQ Profile involves an audit. A full profile encompasses more than the HVAC and related systems, but that



Figure 2. Audit Procedure—Step by Step

is the focus here. The audit establishes a base line for the HVAC system operation. The audit report together with the documentation comprise the HVAC portion of the IAQ Profile.

The audit procedure as described is primarily geared for existing schools. For new facilities some aspects of an audit will be accomplished during commissioning. By either course, an information base resource is established for future guidance. The audit for an existing school begins with a conference with the school principal and key support staff members, followed by a walk through inspection, a review of documentation, and measurement of appropriate IAQ parameters. The audit culminates in a written report. Items to be covered by the audit are listed in Figure 2. Measurement of the listed environmental parameters is a matter of judgement but will usually be limited to areas with past problems. Knowledge of outdoor ventilation rates is important, but measurement is often made difficult by system physical characteristics and weather conditions.

The report must set forth standards of performance established by the design or operating experience. These include space operating temperatures, design relative humidities, ventilation rates and normal hours of system operation. The report should locate profile documentation and inventory key tools or components not otherwise identified in the documentation. Other features are IAQ problem history, evaluation of housekeeping and maintenance, condition of equipment, identification of pollution sources or concern and recommendations for future changes, servicing, replacement and upgrading.

The auditing procedure is performed as an investment in future problem prevention and should be repeated periodically. How often must depend upon the resources and judgement of the district facilities manager. An update every three to five years, in the absence of problems, should be considered.

Documentation

The contract documents, drawings and specifications convey the designers

intent to contractors to produce a suitable building and an HVAC system that is capable of providing a comfortable and, within its capability, a healthy environment. This documentation, plus a record of all significant changes occurring during construction, becomes an indispensable tool for operation and maintenance.

Operation and maintenance manuals are produced by the designer, the system commissioner or the contractor. A complete description of the utility and content of these manuals is found in ASHRAE Guideline 4-1993, noted under References. See Figures 3 & 4 for representative contents. These are augmented with valve identification diagrams, shop drawings and manufacturers data describing equipment, detailed instructions, and spare parts lists. Add to these the air and water balancing report, equipment test reports, the commissioning report, and copies of inspection certificates issued by insuring and government agencies. This list becomes the foundation for training and guidance for proper use of the HVAC system. Prudent management will diligently guard this valuable and, over time, increasingly irreplaceable resource. However, such protection must not restrict access to those who need it most when dealing with planned and unplanned operation and maintenance. Duplicates of some of the documents are usually desirable. The locations and the persons in responsible charge should be recorded.

The audit of an existing school may reveal that some of the vital documents are missing. Replacement of essential information is likely to be costly and arduous, but there is hardly a reasonable alternative. It is not unusual to find the chief resource lies in the head of an operating engineer who has spent years with the system. Filling in the missing material—or at least the most vital elements—may necessitate engaging a professional engineering firm.

The documentation can also be extremely useful to contractors and consulting engineers when changes to the building are undertaken. Environmental specialists tracking the cause of serious IAQ problems also need these materials. One caveat: Don't lend any items out without taking steps—even extraordinary ones—to guarantee their return.



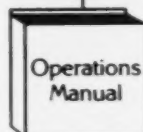
Part I Operation Instructions

Descriptions:

Building, HVAC Systems, (Flow Charts), Control System, Operating Modes.

Procedures:

Starting & Stopping, Operating Mode Changeover (Schedules), Emergency, Energy Conservation, Problem Handling.



Part II Performance Verification

Description:

Design Criteria (Space, Air, Water Heat Gain, Loss Parameters), Normal Range of Parameters (Temperature, Flows)

Procedures:

Monitoring, Logging, Recording, Reporting, Information Source Directory.

Figure 3. Operations Manual Description

Training

Fundamental to the achievement of acceptable indoor air quality are the training and education of all those sharing the goal as expressed earlier. The breadth of those involved extends beyond maintenance personnel and occupants to parents, contractors, administrators, right up to school board members.

All employees, including principals and administrators, need to be informed about basic aspects of IAQ: how the HVAC systems provide control of the air quality including thermal control; school system policy and protocol for handling complaints; and the lines and manner of appropriate communication with occupants, parents and other concerned parties. Underscoring the value of such extensive training is a recent study of buildings with IAQ problems showing that the strongest correlation with symptoms was an inadequate system for dealing with environmental complaints. Custodians, even those with limited responsibility for

operation of the HVAC, are "front line" representatives. Accordingly, some instruction in system basics, emergency and problem handling is appropriate.

The responsibilities and qualifications for maintenance and operations personnel found in existing job descriptions should include those relating to indoor air quality. The operating and maintenance manuals furnished at the completion of an HVAC installation become text books for the training of operators and maintainers. Hands-on demonstration of operation and component maintenance is essential. Planning for training is best initiated through a design services agreement that provides for participation by the design engineer in the training program. The construction contract specifications should delineate contractor, subcontractor, and vendor responsibilities.

The amount of time devoted to training will depend upon the size and complexity of the project. Effectiveness of instruction largely depends upon the competence of both those providing and receiving training and the importance placed upon such training by the facilities manager. Content of the instructional material should be geared to the needs of the trainees. It is often more effective if the program provides for expert post-session consultation.

Some districts designate individuals for primary operation and maintenance responsibilities for a new school *during design*. That designee can then participate in the design review and later monitor the progress of construction. This is a depth of training for which sessions at the completion of the installation can not fully substitute.

Operators need to know what, how and why information relating to the HVAC system performance is to be observed and logged. Maintenance schedules and completion reporting procedures must be preplanned. Completion reports are sometimes fragmentary, even unreliable. Therefore, supervisors must be trained to check. In one instance the coils of unit ventilators were scheduled to be cleaned regularly. A check following receipt of a series of satisfactory completion reports revealed those coils were *incapable* of being cleaned.

Guidance in record keeping procedures is normally provided by district supervisors. Training for code compliance, IAQ complaint handling, problem

Part I Inventory

System Components, Equipment Maintenance Instructions, Spare Parts Lists, Catalog Data, List and Location of On-Site Spare Parts, Supplies, Tools, Material Safety Data Sheets (From Vendors).



Part II Maintenance Program

Planned, Preventive, Corrective Maintenance Instructions;

Water Treatment Procedures;

Storage of Pesticides; Chemicals

Maintenance Program Calendar;

Assistance Directory.

Figure 4. Maintenance Manual Description

diagnosis, reporting, and resolution is also usually assigned to district staff. Maintenance specialist training may also include attendance at schools or seminars conducted by manufacturers and trade organizations. Measurements of IAQ parameters, temperature, humidity, air flow, CO₂, volatile organic compounds, particulates, and microbes require both proper instrumentation and expertise. District capabilities are commonly limited to the first three or four. For more extensive measurement, professional consultants should be engaged. All diagnostic tools require regular calibration. Fast reading electronic instruments can facilitate investigations. Following product research relating to accuracy and reliability as well as cost, digital reading instruments that can facilitate problem investigations can be a worthy investment. Time liness of measurement can not be overlooked. Evidence of problems can be quite fleeting.

Commissioning

HVAC commissioning is a procedure undertaken to —

- verify that performance meets design intent;
- compile the documentation previously described;
- train operation and maintenance personnel.



Meeting these objectives can result in a favorable beginning for any HVAC system. Historically, commissioning has taken many forms. Some have worked well, but not all. A comprehensive commissioning procedure, commencing in the early phases of design and continuing through initial operation and training, can offer assurance that performance objectives are met.

The commissioning effort may be performed by an agency with sufficient background in design, construction, and operation, but which is independent of the design team and contractors. It may alternately be assigned as a responsibility of the design engineer, a member of the school district staff, or the HVAC contractor. Regardless, the elements of the procedure, fully described in ASHRAE Guideline 1-1989, must be carried out. Many of the commissioning functions set forth in this document are normally performed by the design engineer and HVAC contractor. Consequently, there are potential cost tradeoffs when an independent agency is to be used. Experience indicates that fees for an independent agency will increase the total construction budget by 1 to 3%. This could be recouped by cost savings for energy and avoidance of excessive shake-down period corrections. Using the design engineer or the HVAC contractor is likely to reduce the overall cost but at the sacrifice of independent evaluation and performance.

The adoption of commissioning following the ASHRAE Guideline, by reference or as modified to suit the project (including budget constraints), must be decided early. If the design engineering firm is being considered for the task, the optimum time for fee negotiations is in advance of contracting for design and post design services. An alternate fee proposal may help. Even with a decision to opt for an independent agency, this should be known to the design firm in advance of its fee preparation and any effect it will have upon the scope of construction work to be covered by the bidding documents.

Preparation of schedules and description of preventive and planned maintenance procedures are included under the maintenance manual descriptions in the ASHRAE Guidelines. These may be tailored to the district's system, e.g. index cards, software files, by the commissioning agent or by a facilities management employee.

Computerese Acronyms

BAS
Building Automation Systems
BACnet
Data Communication Protocol for Building Automation and Control Networks
CAD
Computer-Aided Design
CADD
Computer-Aided Drafting and Design
CAFM
Computer-Aided Facilities Management
CMMS
Computerized Maintenance Management Systems
DDC
Direct Digital Control
LAN
Local Area Network (Distance between hard-wired devices usually under a mile)
WAN
Wide Area Network, Utilizing Telecommunication Transmission

Commissioning procedures are also appropriate for existing systems when changes have occurred to the building. Without adequate compensatory alterations to the HVAC, air balance and control performance will deteriorate. Base line documentation gradually becomes outdated. The ASHRAE Guideline can be helpful in developing a scope of work for recommissioning.

Computerization

School systems are increasing their use of computers, terminals and software to enhance the effectiveness of school facilities management. Computerization can improve communications, reinforce training, control inventory, monitor and control environmental conditions from multiple locations, render record keeping and access much more manageable, reduce response time in problem handling, conserve energy, improve budget control and allocations, save manpower, and — — The list is limited only by our own creativity.

More than a wish list, some of these attributes — a reality in industry — are beginning to benefit educational institutions. University experience has prepared the way for public school districts. There are districts currently using computers for some of the purposes displayed above. For many, the concept is in the future. Progress is

limited by budget, available personnel, computer expertise, and currently available, constantly evolving hardware and software.

Specific to HVAC/IAQ, computerized management can be utilized to command, monitor and log equipment status (on-off), key parameters (e.g., chilled water temperature, CO₂ concentrations), perform trend and event logging, issue work orders for scheduled and planned maintenance, store equipment descriptions and maintenance instructions for rapid retrieval, and record problem histories for future reference.

Thoughtful planning is a prerequisite to embarking upon Computer-Aided Facilities Management (CAFM — see acronym inset). Computerization is best undertaken as a stepped process. In fact, building automation systems already installed or being specified for new schools could become components. Here is encountered a difficulty. An integrated common system must have satellite systems that can communicate with the central processing unit. Building Automation Systems (BAS) of different manufacturers must therefore be able to speak a common language or have translators do it. No such lingua franca exists, but BACnet, an ASHRAE development, is nearing completion. This inability has restricted facilities comprising multiple buildings to the products of one manufacturer in order to accomplish networking. For future projects, specifying DDC (direct digital control) and BAS compatibility with BACnet software architecture is a prudent preparation. CAFM software packages are currently available for many functions of facility management of multiple buildings. Several can interface with Computer-Aided Drafting and Design (CADD). An early step to consider in computerization is an in-house CADD capability. Architectural and engineering designs for new schools can be stored, electronically displayed, printed and altered for renovations. Many architectural/engineering firms employ CADD to prepare contract documents (which may be copyrighted). Specifying the furnishings of a CADD project file compatible with your system (or future system) and software is an imperative consideration. Several standardized graphics formats exist to facilitate use of software files produced by different programs.



The hardware network configurations for the District must be planned. This involves both short and long term functional analyses. Network pathway options are likely to broaden as expanded use of fiber optics and wireless transmission occurs facilitating communication with remote terminals. Software programs must also be evaluated, not only for functional requirements, but for reliability, user friendliness, supplier stability and hardware compatibility. CAFM networking for HVAC/IAQ may effectively involve a shared arrangement with security, space planning, school administrative, and educational functions. Few facilities managers or staff members have sufficient knowledge for such planning. Outside expertise may help. Since many districts share similar interests, a cooperative venture for planning is a consideration.

The constraints of budget, expertise and technology direct both caution and a well timed step by step approach. Considering the ultimate benefits computerization offers, the extremes of moving too fast (risking serious setbacks) and doing nothing are undesirable.

Common Causes of IAQ Problems Related to HVAC

The spotlight is on the air systems and spaces served by them. However the HVAC/IAQ problems noted may actually originate with deteriorated, dirty cooling towers; malfunctioning refrigeration equipment and pumps; clogged water strainers; unserviceable automatic controls; or incorrectly sized room units.

Inadequate Ventilation

- **Improper air balance:** **room air supply:** measure outlet air flow in problem locations and compare to design • observe air flow movement at doorways with smoke gun to verify positive pressurization of classrooms (and the entire building) • check outlet dampers for tampering • check for air stream obstructions, such as books piled on sill grilles — **outdoor air supply:** look for obstructions, such as trash, leaves, snow at intake louver and screen • verify outdoor air damper opens to proper minimum position and damper control performs correctly — **local exhaust:** check air patterns and flow velocities at hood or

register • measure air flows regularly at laboratory, kiln and shop hoods as a safety check • observe air movement at doorways for inward flow to science labs to contain odors — **building changes:** confirm that HVAC system has been suitably modified and air systems rebalanced to accommodate changes in space and internal energy use.

- **Dysfunctional supply and exhaust systems:** **fans:** check speed as indicated in air balance report • replace worn, slipping belts with matched sets for multiple belt drives • verify belt guards are in place • check filter condition by observation, pressure drop or compliance with replacement schedule — **supply air ducts:** inspect supply ducts and air handling equipment casings for corrosion and leakage — **exhaust air ducts:** check exhaust outlets for obstruction • performance check automatic dampers and controls • examine for corrosion and leakage.

Malfunctioning Controls

- **Improper settings:** regularly check system controllers and space thermostat settings • compare settings to temperature readings by calibrated instrument (preferably a digital thermometer) • verify concealed adjustment integrity • evaluate any reasons for adjustment shifts from design criteria.
- **Inadequate servicing:** review procedures and staff/contractor capabilities for operation and maintenance.

Excessive Humidity

Verify chilled water and air supply temperatures are not above design

- check for improper air balance
- observe condition of cooling coils
- clean dirty coils thoroughly* • check building for negative pressure and inflow of warm humid outdoor air
- check for vapor barrier breaches such as open windows, doors • review system changeover procedures and compliance.

* Dirt accumulations on coils impair heat transfer effectiveness. Improving filtration efficiency can avoid or delay the need for coil and duct cleaning. Specialized tools and experienced, reliable contractors are often required for such cleaning. Standard procedures prepared by the National Air Duct Cleaning Association offer guidance.

Low Humidity

Check building for negative pressure and inflow of cold air.

High or Low Space Temperatures

Check for causes of improper air balance, dysfunctional air systems, malfunctioning controls • inspect for abnormal heat gain as caused by computers, open or missing solar shades or overcrowding.

Odors, Irritating Vapors

- **Building materials:** avoid by selecting low emitting building materials • schedule refurbishing during periods of extended vacancy.
- **HVAC System housekeeping:** clean and dry wetted carpets promptly • replace contaminated carpets and ceiling tiles subject to fungal reinfestation • routinely clean HVAC equipment, especially drain pans and wet coils (without concurrent removal of dirt accumulations the effectiveness of biocides is diminished. Some biocides are potentially harmful to occupants). • check effectiveness of drain pan water removal • verify air system drain traps are primed • inspect duct linings for wetness and microbial growth.
- **Air Quality:** observe that labs, shops and kitchens have inflow of air from adjacent spaces • verify hood operation • evaluate outdoor air for acceptable quality • smoke test to assure noxious exhaust air and plumbing vent air are not being induced into outdoor air intake.
- **Inadequate source control:** verify occupant activities do not generate odors, such as unhooded science experiments • use only suitable housekeeping materials non-injurious to humans.

References

The following sources are suggested for further information.

Operation and Maintenance Guidance

- Indoor Air Quality Management Program, 1989, Anne Arundel County Public Schools, Annapolis, MD.
- Building Air Quality, A Guide for Building Owners and Facilities Managers (1991) EPA, NIOSH, Washington, DC.



INDOOR AIR QUALITY

- Petrocelli, K. Managing Physical Plant Operations (1994) The Fairmont Press, Lilburn, GA.

- ASHRAE Chapter 35. Operation and Maintenance Management (1991) HVAC Applications Handbook, ASHRAE, Atlanta, GA.

Documentation

- ASHRAE Guideline 4-1993. Preparation of Operating and Maintenance Documentation for Building Systems. ASHRAE, Atlanta, GA.

Commissioning

- ASHRAE Guideline 1-1989. Guideline for the Commissioning of HVAC Systems.

Ventilation

- ASHRAE Standard 62-1989. Ventilation for Acceptable Indoor Air Quality.

Computerization

- Amistadi, H. A Review of Software for Computer-Aided Facilities Management, (Nov. 1994) p. 50 Engineering Systems, Business News Publishing Co. Troy, MI
- ASHRAE Chapter 36. Computer Applications, 1991 HVAC Applications Handbook

- ASHRAE BACnet—A Data Communication Protocol for Building Automation and Control Networks. Working draft 2, (1993). Draft 3 is in preparation.

Other Indoor Air Quality Technical Bulletins produced by the Maryland State Department of Education

- Guidelines for Controlling Environmental Tobacco Smoke in Schools
- Guidelines for Controlling Indoor Air Quality Problems Associated with Kilns, Copiers, and Welding in Schools
- Air Cleaning Devices for HVAC Supply Systems in Schools
- Carpet and Indoor Air Quality in Schools
- Interior Painting and Indoor Air Quality in Schools
- Science Laboratories and Indoor Air Quality in Schools
- Selecting HVAC Systems for Schools
- Maintaining Acceptable IAQ during the Renovation of a School

Maryland State Board of Education

Christopher T. Cross, President

Christopher E. Grant, Vice President

Edward Andrews, George W. Fisher, Sr.,

Morris Jones, Rose LaPlaca,

Joan C. Maynard, Andrienne L. Ottaviani,

Harry D. Shapiro, Walter Sondheim, Jr.,

Edmonia T. Yates, Tracy M. Tucker
(Student Member)

Nancy S. Grasmick
Secretary/Treasurer of the Board
State Superintendent of Schools

A. Skipp Sanders
Deputy State Superintendent for
Administration

Joan M. Palmer
Deputy State Superintendent for School
Improvement

Raymond H. Brown
Assistant State Superintendent of Business
Services

Allen C. Abend
Chief, School Facilities Branch

Parris N. Glendening Governor

Bulletin Review Committee

William A. Esposito, Jr.
Technical Representative
Building Owners & Managers
Association, Intl.

Ralph Giffin
Director of Facilities Management
Washington County, Maryland
Public Schools

Jack L. Halliwell
President
Halliwell Engineering Associates

Daniel LaHart
Environmental Issues Program Manager
Anne Arundel County, Maryland
Public Schools

James Lewis
Program Administrator
Maryland Department of the Environment

Tim Long
Supervisor of Maintenance
Charles County, Maryland
Public Schools

Ralph Luther
Acting Asst. Superintendent for
Support Services
Anne Arundel County, Maryland
Public Schools

Laura Olsen
Operations and Safety Assistant Manager
Frederick County, Maryland
Public Schools

Richard J. Shaughnessy
Program Manager
Indoor Air Pollution Research
University of Tulsa

Michael Sines
Supervisor of Maintenance & Operations
Garrett County, Maryland
Public Schools

J. Michael Sweeney
Health Consultant, MOSH
Maryland Department of Licensing
& Regulation

B.T. Tamblin
President
Engineering Interface, Ltd.

Robert Thompson
Environmental Engineer
Indoor Air Division
U.S. Environmental Protection Agency

Thomas Welsh
Maintenance Engineer
Maryland Department of General Services

The Maryland State Department of Education does not discriminate on the basis of race, color, sex, age, national origin, religion, or disability in matters affecting employment or in providing access to programs. For inquiries related to Department policy, please contact:

Equity Assurance and Compliance Branch
Maryland State Department of Education
200 West Baltimore Street
Baltimore, Maryland 21201
(410) 767-0425 Voice
(410) 333-6442 TTY/TDD
(410) 767-0431 FAX

This Bulletin was developed and published, in part, with funds from the U.S. Environmental Protection Agency, Indoor Air Division.

Participation on The Bulletin Review Committee does not imply agreement with the entire content of this bulletin.



Maryland State Department of
EDUCATION

Schools for Success

Douglas Sidney Graphic Design